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BOX: PATENT APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231

Re: Application of Eiji OGAWA
IMAGE DISPLAY METHOD AND IMAGE DISPLAY UNIT
Our Reference: Q58695

Dear Sir:

Attached hereto is the application identified above including the specification, claims, executed Declaration and Power of Attorney, four (4) sheets of drawings, one (1) priority document, executed Assignment and PTO Form 1595.

The Government filing fee is calculated as follows:

Total Claims	28 - 20 =	8 x $18 =	$ 144.00
Independent Claims	2 - 3 =	0 x $78 =	$ 000.00
Base Filing Fee	($690.00)		$ 690.00
Multiple Dep. Claim Fee	($260.00)		$ 000.00
TOTAL FILING FEE			**$ 834.00**
Recordation of Assignment Fee			$ 40.00
TOTAL U.S. GOVERNMENT FEE			**$ 874.00**

Checks for the statutory filing fee of $ **834.00** and Assignment recordation fee of $ **40.00** are attached. You are also directed and authorized to charge or credit any difference or overpayment to Deposit Account No. 19-4880. The Commissioner is hereby authorized to charge any fees under 37 C.F.R. 1.16 and 1.17 and any petitions for extension of time under 37 C.F.R. 1.136 which may be required during the entire pendency of the application to Deposit Account No. 19-4880. A duplicate copy of this transmittal letter is attached.

Priority is claimed from:

Japanese Patent Application	Filing Date
(patent) 232576/1999	August 19, 1999

Respectfully submitted,
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IMAGE DISPLAY METHOD AND IMAGE DISPLAY UNIT

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to an image display method and an image display unit, and in particular to an improvement in the output brightness characteristic between an input signal and its output brightness.

Description of the Related Art

In the medical field, a human body is irradiated with radiation, the radiation-transmitted image is recorded on X-ray film, and while the X-ray film recorded with radiation-transmitted image is being held to a light source or schaukasten (which is a box for observing X-ray film), the transmitted light image is observed and analyzed.

On the other hand, because of the recent development of digital technology it is becoming standard to digitize and process the aforementioned radiation-transmitted image by computers. It has also become possible to observe and analyze the aforementioned radiation-transmitted image stored as a digital image on a server, etc., by displaying it immediately on an image display unit, such as a cathode-ray tube (CRT) display unit, connected to a network, without outputting it to X-ray film for every display.

If an image as viewed with the X-ray film held to the schaukasten is compared with an image as viewed with it displayed on a CRT display unit, etc., incidentally, there is a difference

in how the two images look.

The image display unit, such as a CRT display unit, etc., is generally grouped into two types. One type has an output brightness characteristic in which an input image signal S and its output brightness L are in a linear relationship (Fig. 3A). Another type has an output brightness characteristic in which an input image signal S and a logarithmic value Y (= $\log_{10}(L)$) of its output brightness L are in a linear relationship (Fig. 3B). The display unit having the output brightness characteristic shown in Fig. 3B is most suitable to make the human eyes feel contrast (hereinafter referred to as visual effect).

On the other hand, the X-ray film, as shown in Fig. 4, exhibits an output brightness characteristic in which an input image signal S and its output density D are approximately linear, but the sensitivity of the output density D with respect to the input image signal S is reduced at the low signal value region. Also, when viewing an image recorded on X-ray film of such an output brightness characteristic, with the film held to the schaukasten, an image portion of high density is recognized as an image portion of low brightness and an image portion of low density is recognized as an image portion of high density, as shown in Fig. 4B. Therefore, for the image viewed with the X-ray film held to the schaukasten, the sensitivity of the output brightness (logarithmic value) to the value of an input signal becomes lower in the low signal value region corresponding to the image portion of low density than in other intermediate and high signal value regions.

Thus, between an image as viewed with X-ray film held to the schaukasten and an image as viewed with it displayed on an image display unit such as a CRT display unit, etc., there is a difference in the sensitivity of the output brightness in the low signal value region. Because of this, there are cases where doctors, etc., who are used to the analysis of an image output to X-ray film which is the traditional method of analyzing an image, will feel a sense of incompatibility with respect to an image displayed on an image display unit. There is also a possibility that a sense of incompatibility such as this will inhibit disturb accurate analysis.

SUMMARY OF THE INVENTION

The present invention has been made in view of the drawbacks found in the prior art. Accordingly, it is the primary object of the present invention to provide an image display method and an image display unit which are capable of displaying an image that has the same visual effect as an image output to X-ray film (hereinafter referred to as feeling of contrast).

In the image display method and image display unit of the present invention, a rate of change, which is a change in the output brightness of an input image signal with respect to a change in the value of the image signal, in the low signal value region of the image signal is made smaller than a rate of change in the intermediate and high signal value region of the image signal, so that the same visual effect is obtained as for the case in which an image represented by the image signal is output and viewed as

a gray image to X-ray film.

In accordance with present invention, there is provided an image display method, which has an output brightness characteristic in which a logarithmic value of an output brightness becomes smaller as a value of an input image signal becomes greater, for displaying a visible image that the image signal represents according to the output brightness characteristic, the image display method comprising the step of:

setting the output brightness characteristic so that a rate of change, which represents a change in the logarithmic value of the output brightness with respect to a change in the signal value, in a low signal value region of the image signal becomes smaller than that in an intermediate and high signal value region of the image signal.

Thus, by making the change rate of the logarithmic value of the output brightness in the low signal value region of the input image signal (gradient of the logarithm of the output brightness with respect to the input image signal) smaller than the change rate in the intermediate and high signal value region of the image signal, and by then displaying the image on a CRT display unit, etc., the image can be observed as an image having the same visual effect as the case in which the image is output to X-ray film having a density characteristic in which the change rate of the density in the low signal value region is smaller than that in the intermediate and high signal value region. The transmitted light image is then viewed with this film (hard copy) held to a light

source or schaukasten. Note that a small change rate means the absolute value of the change rate is small. Likewise, a large change rate means that the absolute value of the change rate is large.

It is preferable that the output brightness characteristic be approximately linear over approximately the entire intermediate and high signal value region, because an image more similar in visual effect to the image in the case of outputting it to the aforementioned film can be displayed.

Preferably, a boundary value S_a between the low signal value region and the intermediate and high signal value region is a value in the range of the following Eq. 1 by test and experience. It is also preferable to set the aforementioned output brightness characteristic so that a logarithmic value $Y(S_a)$ of the output brightness at the boundary value S_a is a value in the range of the following Eq. 2.

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max} \quad \ldots (1)$$

$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05 \quad \ldots (2)$$

where S_{max} represents the maximum value of the image signal in the aforementioned output brightness characteristic and Y_{max} represents the maximum value of the logarithmic value of the brightness in the aforementioned output brightness characteristic. Note that an optimum value S_a as the boundary value is a value in the range of the following Eq. 1′. It is optimum to set the logarithmic value

$Y(S_a)$ of the output brightness at this time to $(Y_{max} - 0.15)$.

$$0.16 \times S_{max} \leqq S_a \leqq 0.20 \times S_{max} \quad \cdots (1')$$

In addition, it is desirable that the change rate G in the aforementioned intermediate and high signal value region be a value within the range represented by the following Eq. 3. Optimally the change rate G is $-(2.88/S_{max})$.

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max}) \quad \cdots (3)$$

In the aforementioned image display method of the present invention, the intermediate and high signal value region is further divided into an intermediate signal value region and a high signal value region. It is also preferred to make a change rate in the high signal value region greater than that in the intermediate signal value region (i.e., to make the gradient of the logarithm of the output brightness with respect to an input image signal sharper).

The reason for this is that in the high signal value region, i.e., the low brightness region, a feeling of contrast of a displayed visible image tends to be reduced because of ambient light, so if the change rate in the high signal value region is made greater than that in the intermediate signal value region, a reduction in the feeling of contrast, due to ambient light, can be suppressed.

Preferably, the output brightness characteristic is

approximately linear over approximately the entire intermediate signal value region, and the aforementioned change rate in the high signal value region is made greater. Furthermore, it is preferable that the output brightness characteristic be approximately linear over approximately the entire high signal value region. In this way, an image more similar in visual effect to the image in the case of outputting it to the aforementioned film can be displayed, even if there is an influence of ambient light.

Preferably, a boundary value S_b between the aforementioned low signal value region and the aforementioned intermediate and high signal value region is a value in the range of the following Eq. 4 by test and experience. It is also preferred to set the aforementioned output brightness characteristic so that a logarithmic value $Y(S_b)(= \log_{10}(L(S_b))$ of the output brightness $L(S_b)$ at the boundary value S_b is a value in the range of the following Eq. 5.

$$0.70 \times S_{max} \leqq S_b \leqq 1.00 \times S_{max} \quad \ldots (4)$$

$$Y_{max} - 2.15 \leqq Y(S_a) \leqq Y_{max} - 1.95 \quad \ldots (5)$$

Note that an optimum value S_b as the boundary value is a value within the range of the following Eq. 4′. It is optimum to set the logarithmic value $Y(S_b)$ of the output brightness at this time to $(Y_{max} - 2.03)$.

$$0.80 \times S_{max} \leqq S_b \leqq 0.90 \times S_{max} \quad \ldots (4')$$

In addition, it is desirable that the change rate G in the aforementioned intermediate signal value region be a value within the range represented by the following Eq. 3.

In accordance with the present invention, there is provided an image display unit, which comprises a brightness circuit having an output brightness characteristic in which a logarithmic value of an output brightness becomes smaller as a value of an input image signal becomes greater, for displaying a visible image that the image signal represents according to the output brightness characteristic. In image display unit, the output brightness characteristic in the brightness circuit is set so that a rate of change, which represents a change in the logarithmic value of the output brightness with respect to a change in the signal value, in a low signal value region of the image signal becomes smaller than that in an intermediate and high signal value region of the image signal.

It is preferable that the aforementioned output brightness characteristic of the brightness circuit be approximately linear over approximately the entire intermediate and high signal value region.

Preferably, a boundary value S_a between the low signal value region and the intermediate and high signal value region is a value represented by the aforementioned Eq. 1. It is also preferable to set a logarithmic value $Y(S_a)$ of the output brightness at the boundary value S_a to a value in the range of the aforementioned

Eq. 2. An optimum value S_a as the boundary value is a value in the range of the aforementioned Eq. 1'. It is optimum to set the logarithmic value $Y(S_a)$ of the output brightness at this time to $(Y_{max} - 0.15)$.

Furthermore, it is desirable that the change rate G in the intermediate and high signal value region be a value within a range represented by the aforementioned Eq. 3. Optimally the change rate G is $-(2.88/S_{max})$.

In the aforementioned image display unit of the present invention, the intermediate and high signal value region is similarly divided into an intermediate signal value region and a high signal value region. It is also preferred to make a change rate in the high signal value region greater than that in the intermediate signal value region. In this way, a reduction in a feeling of contrast of a displayed visible image, which is caused by the influence of ambient light, can be suppressed.

Preferably, the output brightness characteristic is approximately linear over approximately the entire intermediate signal value region, and the aforementioned change rate in the high signal value region is made greater. Furthermore, it is preferable that the output brightness characteristic be approximately linear over approximately the entire high signal value region. In this way, an image more similar in visual effect to the image in the case of outputting it to the aforementioned film can be displayed, even if there is an influence of ambient light.

Preferably, a boundary value S_b between the

aforementioned low signal value region and the aforementioned intermediate and high signal value region is a value in the range of the aforementioned Eq. 4 by test and experience. It is also preferred to set the aforementioned output brightness characteristic so that a logarithmic value $Y(S_b)$ (= $\log_{10}(L(S_b))$) of the output brightness $L(S_b)$ at the boundary value S_b is a value in the range of the aforementioned Eq. 5.

Note that an optimum value S_b as the boundary value is a value within the range of the aforementioned Eq. 4'. It is optimum to set the logarithmic value $Y(S_b)$ of the output brightness at this time to $(Y_{max} - 2.03)$.

In addition, it is desirable that the change rate G in the aforementioned intermediate signal value region be a value within the range represented by the aforementioned Eq. 3.

The aforementioned image display method and image display unit of the present invention are more effective in the case where a medical image, particularly an image signal representing a radiation image, is employed as an input image signal.

According to the image display method and image display unit of the present invention, a rate of change in the logarithmic value of the output brightness in the low signal value region of an input image signal is made smaller than that in the intermediate and high signal value region of the image signal, and the image signal is displayed on a CRT display unit. etc. Therefore, the displayed image can be viewed as an image having the same visual

effect as the case in which the image is output to X-ray film having a density characteristic in which a change rate of the density in the low signal value region is smaller than that of the density in the intermediate and high speed value region, and the transmitted light image is viewed with this X-ray film held to a light source or schaukasten.

Therefore, particularly in the medical field, doctors, etc., who are accustomed to the analysis of an image output to X-ray film, can analyze an image displayed on a CRT display unit, etc., without a sense of incompatibility, and perform accurate analysis, based on the image displayed on the CRT display unit, etc., without outputting it to X-ray film.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects and advantages will become apparent from the following detailed description when read in conjunction with the accompanying drawings wherein:

FIG. 1 is a block diagram showing an embodiment of an image display unit of the present invention;

FIG. 2A is a graph showing an output brightness characteristic which represents the relationship between an input image signal and a logarithmic value of its output brightness;

FIG. 2B is a graph showing another output brightness characteristic which represents the relationship between an input image signal and a logarithmic value of its output brightness;

FIG. 3A is a graph showing the output brightness characteristic of a conventional image display unit in which an

input image signal and its output brightness are in a linear relationship;

FIG. 3B is a graph showing the output brightness characteristic of another conventional image display unit in which an input image signal and a logarithmic value of its output brightness are in a linear relationship;

FIG. 4A is a graph showing the output density characteristic of X-ray film which represents the relationship between an input image signal and its output density; and

FIG. 4B is a graph showing the brightness characteristic when the X-ray film of FIG. 4A is held to the schaukasten.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to Fig. 1, there is shown an image display unit in accordance with a preferred embodiment of the present invention. The image display unit 10 is constructed of a brightness circuit 11 and an image display section 12. The brightness circuit 11 has an output brightness characteristic in which an input image signal S and its output brightness L are in a predetermined relationship. The image display section 12 visually displays an image that the input image signal represents in the brightness L output from the brightness circuit 11.

The output brightness characteristic of the brightness circuit 11 is a characteristic in which the logarithmic value Y (= log(L)) of the output brightness L becomes smaller as the value of the input image signal S becomes larger, as shown Fig. 1A. A rate of change $|G_{0-a}|$ ($=|\Delta Y/\Delta S|$: absolute value of the

differentiated value of Y with respect to the differentiated value of S), which represents a change in the logarithmic value Y of the output brightness L with respect to a change in the image signal S, in the low signal value region of the image signal S ($0 \leqq S \leqq S_a$) is set smaller than a rate of change $|G_{a-100}|$ in the intermediate and high signal value region of the image signal ($S_a < S$)($|G_{0-a}| < |G_{a-100}|$). Note that the boundary value S_a between the low signal value region and the intermediate and high signal value region is set to a value in the range of the following Eq. 1'. For instance, it is set to $S_a = 0.18 \times S_{max}$ where S_{max} represents the maximum value of the image signal in the output brightness characteristic.

$$0.16 \times S_{max} \leqq S_a \leqq 0.20 \times S_{max} \quad \ldots \ (1')$$

On the other hand, the logarithmic value Y (S_a) of the output brightness L (S_a) at the boundary value S_a is set to a value in the range of the following Eq. 2. For example, it is set to $Y(S_a) = Y_{max} - 0.15$ where Y_{max} represents the maximum value of the logarithmic value of the brightness in the output brightness characteristic.

$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05 \quad \ldots \ (2)$$

In addition, the rate of change G_{a-100} in the intermediate and high signal value region ($S_a < S$) of the image signal S is set to a value in the range of the following Eq. 3, for example, G_{a-100}

$= - 2.88/S_{max}$.

$$-(3.0/S_{max}) \leqq G_{a-100} \leqq -(2.5/S_{max}) \quad \ldots \ (3)$$

The visible image, displayed on the image display section 12 in the brightness L output from the brightness circuit 11 having the output brightness characteristic thus set, can be observed as an image having the same visual effect (see Fig. 2A) as the case in which the image is output to X-ray film having a density characteristic (see Fig. 4) in which a change rate of the density in the low signal value region is smaller than that of the density in the intermediate and high speed value region, and the transmitted light image is viewed with this X-ray film held to a light source or schaukasten.

Therefore, doctors, etc., who are familiar with the analysis of an image output to X-ray film, can analyze an image displayed on the display section 12 without a sense of incompatibility, and perform accurate analysis, based on the image displayed on the display section 12, without outputting it to the X-ray film.

Note that in the output brightness characteristic of the brightness circuit 11, it is more desirable to set a rate of change $|G_{b-100}|$ in the high signal value region ($S_b \leqq S \leqq S_{max}$) greater than a rate of change $|G_{a-b}|$ in the intermediate signal value region ($S_a \leqq S \leqq S_b$) ($|G_{a-b}| < |G_{b-100}|$). The boundary value S_b between the intermediate signal value region and the high signal value region

is set to a value in the range of the following Eq. 4'. For instance, it is set to $S_b = 0.83 \times S_{max}$.

$$0.80 \times S_{max} \leqq S_b \leqq 0.90 \times S_{max} \quad \ldots (4')$$

On the other hand, the logarithmic value $Y(S_b)$ of the output brightness $L(S_b)$ at the boundary value S_b is set to a value in the range of the following Eq. 5. For example, it is set to $Y(S_b) = Y_{max} - 2.03$.

$$Y_{max} - 2.15 \leqq Y(S_b) \leqq Y_{max} - 1.95 \quad \ldots (5)$$

The visible image, displayed on the image display section 12 in the brightness L output from the brightness circuit 11 having the output brightness characteristic thus set, can be observed as an image having the same visual effect (contrast (see Fig. 2A)) as the case in which the image is output to X-ray film having a density characteristic (see Fig. 4) in which a change rate of the density in the low signal value region is smaller than that of the density in the intermediate and high speed value region, and the transmitted light image is viewed with this X-ray film held to a light source or schaukasten.

While a certain representative embodiment and details have been shown for the purpose of illustrating the present invention, it will be apparent to those skilled in this art that various changes and modifications may be made without departing

from the scope of the invention hereinafter claimed.

In addition, all of the contents of Japanese Patent Application No. 11(1999)-232576 are incorporated into this specification by reference.

What is claimed is:

1. An image display method, which has an output brightness characteristic in which a logarithmic value of an output brightness becomes smaller as a value of an input image signal becomes larger, for displaying a visible image that said image signal represents according to said output brightness characteristic, the image display method comprising the step of:

setting said output brightness characteristic so that a rate of change, which represents a change in a logarithmic value of said output brightness with respect to a change in said signal value, in a low signal value region of said image signal becomes smaller than that in an intermediate and high signal value region of said image signal.

2. The image display method as set forth in claim 1, wherein said output brightness characteristic is approximately linear over approximately the entire intermediate and high signal value region.

3. The image display method as set forth in claim 1, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, and a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$

$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

4. The image display method as set forth in claim 2, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, and a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$
$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

5. The image display method as set forth in claim 1, wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

6. The image display method as set forth in claim 2,

wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

7. The image display method as set forth in claim 3, wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

8. The image display method as set forth in claim 1, wherein said output brightness characteristic is set so that said change rate in the high signal value region of said image signal becomes greater than that in the intermediate signal value region of said image signal.

9. The image display method as set forth in claim 8, wherein said output brightness characteristic is approximately linear over approximately the entire intermediate signal value region and over approximately the entire high signal value region.

10. The image display method as set forth in claim 8, wherein a boundary value S_a between said low signal value region

and said intermediate and high signal value region, a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a, a boundary value S_b between said intermediate signal value region and said high signal value region, and a logarithmic value $Y(S_b)$ of said output brightness at said boundary value S_b are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$
$$0.70 \times S_{max} \leqq S_b \leqq 1.00 \times S_{max}$$
$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$
$$Y_{max} - 2.15 \leqq Y(S_b) \leqq Y_{max} - 1.95$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

11. The image display method as set forth in claim 9, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a, a boundary value S_b between said intermediate signal value region and said high signal value region, and a logarithmic value $Y(S_b)$ of said output brightness at said boundary value S_b are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$

$$0.70 \times S_{max} \leqq S_b \leqq 1.00 \times S_{max}$$

$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

$$Y_{max} - 2.15 \leqq Y(S_b) \leqq Y_{max} - 1.95$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

12. The image display method as set forth in claim 8, wherein said change rate in said intermediate signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

13. The image display method as set forth in claim 9, wherein said change rate in said intermediate signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

14. The image display method as set forth in claim 10, wherein said change rate in said intermediate signal value region

is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

where S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

15. In an image display unit, which comprises a brightness circuit having an output brightness characteristic in which a logarithmic value of an output brightness becomes smaller as a value of an input image signal becomes larger, for displaying a visible image that said image signal represents according to said output brightness characteristic,

the improvement wherein said output brightness characteristic in said brightness circuit is set so that a rate of change, which represents a change in the logarithmic value of said output brightness with respect to a change in said signal value, in a low signal value region of said image signal becomes smaller than that in an intermediate and high signal value region of said image signal.

16. The image display unit as set forth in claim 15, wherein said output brightness characteristic in said brightness circuit is approximately linear over approximately the entire intermediate and high signal value region.

17. The image display unit as set forth in claim 15, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, and a

logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$
$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

18. The image display unit as set forth in claim 16, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, and a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$
$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

19. The image display unit as set forth in claim 15, wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

20. The image display unit as set forth in claim 16, wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

21. The image display unit as set forth in claim 17, wherein said change rate in said intermediate and high signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

22. The image display unit as set forth in claim 15, wherein said output brightness characteristic in said brightness circuit is set so that said change rate in the high signal value region of said image signal becomes larger than that in the intermediate signal value region of said image signal.

23. The image display unit as set forth in claim 22, wherein said output brightness characteristic in said brightness circuit is approximately linear over approximately the entire intermediate signal value region and over approximately the entire high signal value region.

24. The image display unit as set forth in claim 22, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, a logarithmic value $Y(S_a)$ of said output brightness at said boundary value S_a, a boundary value S_b between said intermediate signal value region and said high signal value region, and a logarithmic value $Y\ (S_b)$ of said output brightness at said boundary value S_b are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$

$$0.70 \times S_{max} \leqq S_b \leqq 1.00 \times S_{max}$$

$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$

$$Y_{max} - 2.15 \leqq Y(S_b) \leqq Y_{max} - 1.95$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

25. The image display unit as set forth in claim 23, wherein a boundary value S_a between said low signal value region and said intermediate and high signal value region, a logarithmic

value $Y(S_a)$ of said output brightness at said boundary value S_a, a boundary value S_b between said intermediate signal value region and said high signal value region, and a logarithmic value $Y(S_b)$ of said output brightness at said boundary value S_b are represented by the following equations:

$$0.05 \times S_{max} \leqq S_a \leqq 0.30 \times S_{max}$$
$$0.70 \times S_{max} \leqq S_b \leqq 1.00 \times S_{max}$$
$$Y_{max} - 0.25 \leqq Y(S_a) \leqq Y_{max} - 0.05$$
$$Y_{max} - 2.15 \leqq Y(S_b) \leqq Y_{max} - 1.95$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and Y_{max} is the maximum value of the logarithmic value of the brightness in said output brightness characteristic.

26. The image display unit as set forth in claim 22, wherein said change rate in said intermediate signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

27. The image display unit as set forth in claim 23, wherein said change rate in said intermediate signal value region is represented by the following equation:

$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

28. The image display unit as set forth in claim 24, wherein said change rate in said intermediate signal value region is represented by the following equation:

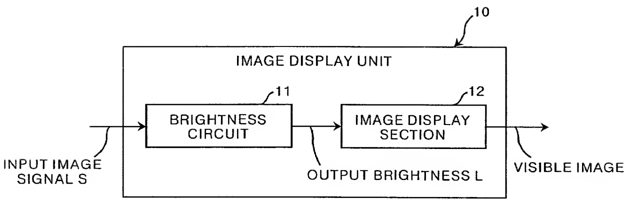
$$-(3.0/S_{max}) \leqq G \leqq -(2.5/S_{max})$$

in which S_{max} is the maximum value of the image signal in said output brightness characteristic and G is said change rate.

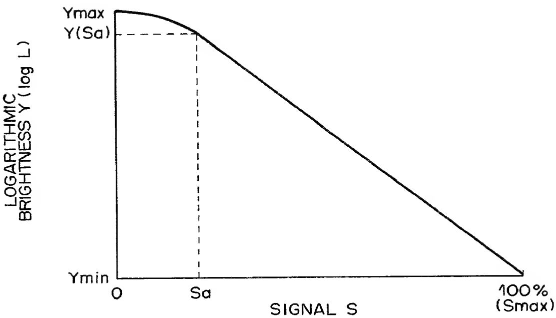
ABSTRACT OF THE DISCLOSURE

Disclosed herein is an image display unit comprising a brightness circuit which has an output brightness characteristic in which the logarithmic value of the output density of an input image signal becomes smaller as the value of the image signal becomes larger. The output brightness characteristic is set so that a rate of change, which represents a change in the logarithmic value of the output brightness with respect to a change in the signal value, in the low signal value region of the image signal becomes smaller than that in the intermediate and high signal value region of the image signal.

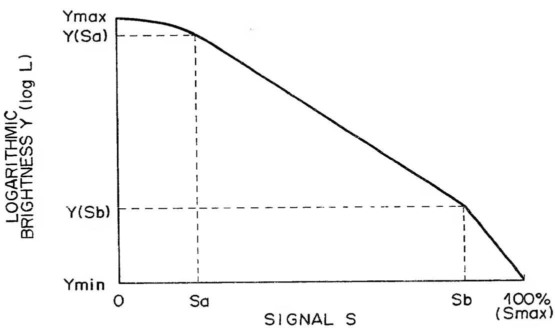
FIG.1


10
IMAGE DISPLAY UNIT
11
12
BRIGHTNESS CIRCUIT
IMAGE DISPLAY SECTION
INPUT IMAGE SIGNAL S
OUTPUT BRIGHTNESS L
VISIBLE IMAGE

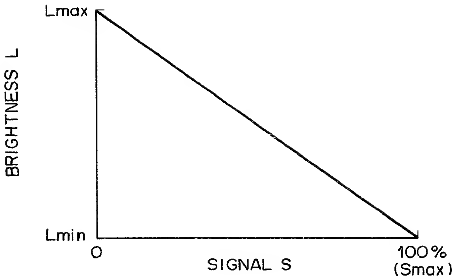
F I G. 2A


Ymax
Y(Sa)
LOGARITHMIC BRIGHTNESS Y (log L)
Ymin
0
Sa
100%
(Smax)
SIGNAL S

F I G. 2B


Ymax
Y(Sa)
LOGARITHMIC BRIGHTNESS Y (log L)
Y(Sb)
Ymin
0
Sa
Sb
100%
(Smax)
SIGNAL S

F I G . 3A


Lmax
BRIGHTNESS L
Lmin
0
SIGNAL S
100%
(Smax)

F I G . 3B

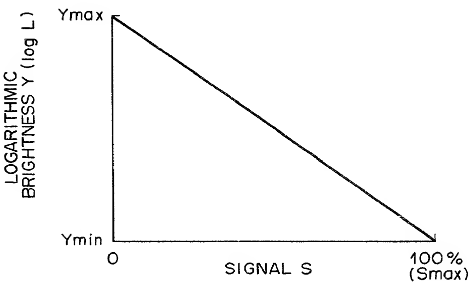

Ymax
LOGARITHMIC BRIGHTNESS Y (log L)
Ymin
0
SIGNAL S
100%
(Smax)

FIG. 4A

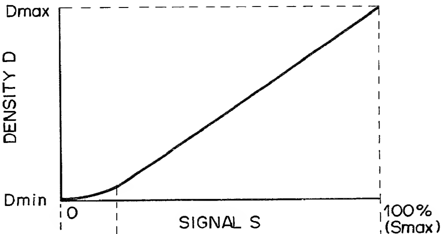
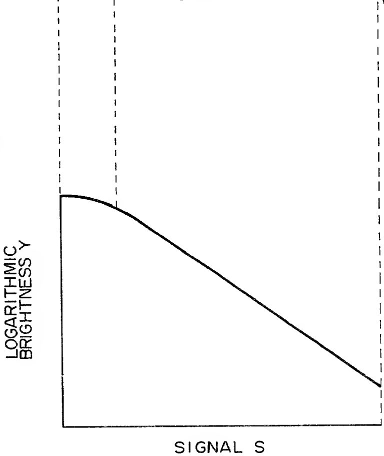

Dmax
DENSITY D
Dmin
O
SIGNAL S
100%
(Smax)

FIG. 4B


LOGARITHMIC BRIGHTNESS Y
SIGNAL S

PA4154US

Declaration and Power of Attorney for Patent Application

特許出願宣言書及び委任状

Japanese Language Declaration

日本語宣言書

下記の氏名の発明者として、私は以下の通り宣言します。

As a below named inventor, I hereby declare that:

Eiji Ogawa

私の住所、私書箱、国籍は下記の私の氏名の後に記載された通りです。

My residence, post office address and citizenship are as stated next to my name, c/o Fuji Photo Film Co., Ltd., 798 Miyanodai, Kaisei-machi, Ashigarakami-gun, Kanagawa-ken, Japan

下記の名称の発明に関して請求範囲に記載され、特許出願している発明内容について、私が最初かつ唯一の発明者（下記の氏名が一つの場合）もしくは最初かつ共同発明者であると（下記の名称が複数の場合）信じています。

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

"IMAGE DISPLAY METHOD AND IMAGE DISPLAY UNIT"

上記発明の明細書（下記の欄でX印がついていない場合は、本書に添付）は、

the specification of which is attached hereto unless the following box is checked:

☐ ＿月＿日に提出され、米国出願番号または特許協定条約

国際出願番号を＿＿＿＿＿＿とし、

（該当する場合）＿＿＿＿＿＿に訂正されました。

☐ was filed on ＿＿＿＿＿＿
as United States Application Number or
PCT International Application Number
＿＿＿＿＿＿ and was amended on
＿＿＿＿＿＿ (if applicable).

私は、特許請求範囲を含む上記訂正後の明細書を検討し、内容を理解していることをここに表明します。

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

私は、連邦規則法典第37編第1条56項に定義されるとおり、特許資格の有無について重要な情報を開示する義務があることを認めます。

I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

Japanese Language Declaration

(日本語宣言書)

私は、米国法典第35編第119条(a)-(d)項又は第365条(b)項に基き下記の、米国以外の国の少なくとも一カ国を指定している特許協力条約第365条(a)項に基づく国際出願、又は外国での特許出願もしくは発明者証の出願についての外国優先権をここに主張するとともに、優先権を主張している本出願の前に出願された特許または発明者証の外国出願を以下に、枠内をマークすることで、示しています。

I hereby claim foreign priority under Title 35, United States Code, Section 119(a)-(d) or 365(b) of any foreign application(s) for patent or inventor's certificate, or 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed.

Prior Foreign Applications
外国での先行出願

Priority Not Claimed
優先権主張なし

(Number) (番号)	(Country) (国名)	(Day/Month/Year Filed) (出願年月日)	優先権主張なし
(patent) 232576/1999	Japan	19/08/1999	☐
			☐
			☐

私は、第35編米国法典119条(e)項に基づいて下記の米国特許出願規定に記載された権利をここに主張致します。

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(Application No.) (出願番号)	(Filing Date) (出願日)

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I hereby claim the benefit of Title 35, United States Code Section 120 of any United States application(s), or 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of Title 35, United States Code Section 112, I acknowledge the duty to disclose any material information which is material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application:

(Application No.) (出願番号)	(Filing Date) (出願日)	(Status: Patented, Pending, Abandoned) (現況：特許許可済、係属中、放棄済)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Japanese Language Declaration

(日本語宣言書)

委任状： 私は、下記の発明者として、本出願に関する一切の手続きを米国特許商標局に対して遂行する弁理士又は代理人として、下記のものを指名致します。(弁護士、又は代理人の氏名及び登録番号を明記のこと)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith *(list name and registration number)*

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住所	Residence
国籍	Citizenship
郵便の宛先	Post office address

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